PART I: Multiple choice questions

Only one of the choices given in each question is the correct answer. For each multiple choice question, please circle your chosen answer. No explanation for your choice is required. Each multiple choice problem is worth 5 points.

1. Two identical pulses of opposite amplitude travel along a stretched string and interfere destructively. The ends of the string are not fixed. Which of the following statements is true?

(a) There is no instant at which the string is completely straight.

(b) When the two pulses interfere, the energy of the pulses is momentarily zero.

(c) There is exactly one point on the string that does not move up or down.

(d) There are several points on the string that do not move up or down.

(e) After the pulses pass each other, their shapes are distorted.

2. A stone is thrown into a quiet pool of water, creating outgoing circular waves from the point of impact. Ignoring the friction of the fluid, the amplitude of the waves falls off with distance r from the impact point as

(a) $1/r^2$

(b) $1/r^{3/2}$

(c) $1/r$

(d) $1/r^{1/2}$

(e) The amplitude remains constant as r increases.

3. You stand on a platform at a train station and listen to a train approaching the station at constant velocity. The conductor on the train hears the train whistle sound at constant intensity and frequency. While the train approaches, but before it arrives, what do you hear?

(a) The intensity and the frequency of the sound both increasing.

(b) The intensity and the frequency of the sound both decreasing.

(c) The intensity increasing and the frequency decreasing.

(d) The intensity decreasing and the frequency increasing.

(e) The intensity increasing and the frequency remaining the same.

(f) The intensity decreasing and the frequency remaining the same.

4. The radio station KPIG announces their broadcast frequency as "107 oink 5" (that is, 107.5 on your FM dial). What is the corresponding wavelength of the waves they use to broadcast their signal?

(a) 140 nm

(b) 4.2 cm

(c) 2.8 m

(d) 42 m

(e) 2.8 km

5. When light is either reflected or refracted, the quantity that does not change in either process is its

(a) direction of travel

(b) dispersion

(c) frequency

(d) speed

(e) wavelength

6. A converging lens of focal length f forms a sharp image of an object on a screen. What is the smallest possible distance between the object and the screen?

(a) 0

(b) f

(c) $2f$

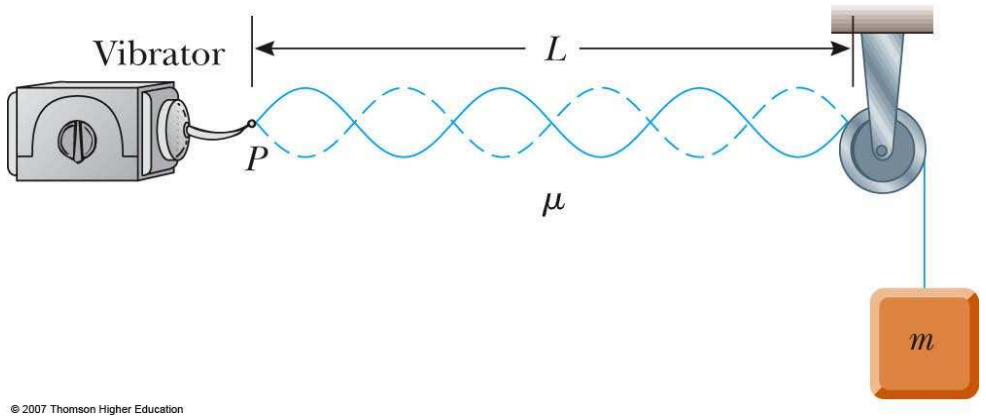
(d) $4f$

(e) none of the above

PART II: Short problems

To earn full credit on the following problems, you must exhibit the steps that lead to your final result (and will depend on the clarity of your method of solution as well as on your final answer). Problem 7 and 8 are worth 20 points each, and problem 9 is worth 30 points.

7. In the arrangement shown in the figure below, a block is hung from a string (with linear mass density $\mu = 2$ g/m) that passes over a fixed pulley (whose mass is negligible). The string is connected to a vibrator (of constant frequency f), and the length of the string between point P and the pulley is $L = 2$ m. When the mass m of the block is either 16 kg or 25 kg, standing waves are observed. However, no standing waves are observed with any mass between these values.



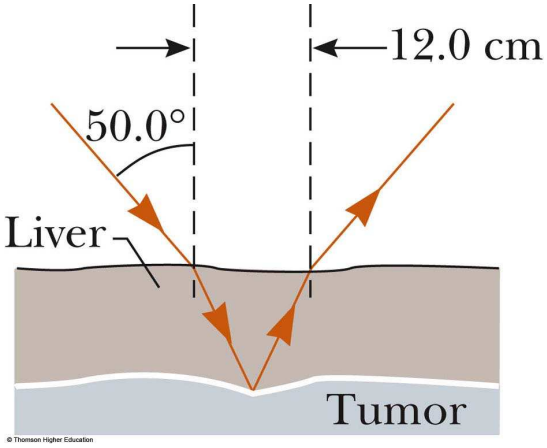
NOTE: The shape of the standing wave shown above is for illustrative purposes only and does not necessarily correspond to any of the masses given in this problem.

(a) What is the frequency f of the vibrator?

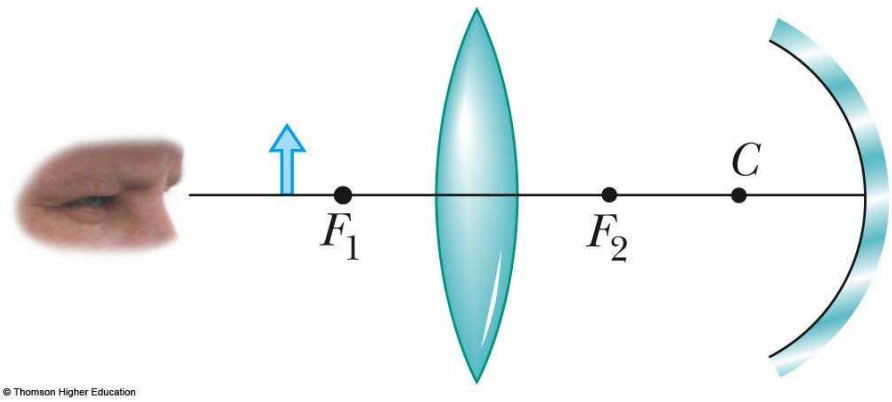
HINT: The hanging block provides tension for the string. The greater the tension of the string, the smaller the number of nodes in the standing wave. Assume that a node exists at the location of the vibrator.

(b) What is the mass of the heaviest block for which standing waves could be observed?

8. A narrow beam of ultrasonic waves reflects off a liver tumor as illustrated in the figure below. The speed of the wave is 10% less in the liver than in the surrounding medium (located above the liver in the figure below). Determine the depth of the tumor.



9. The figure below depicts a thin converging lens and a concave mirror. The radii of curvature of the front surface and back surface of the lens are equal and each is given by 10 cm. The radius of curvature of the spherical mirror (whose center of curvature is denoted by C) is 8 cm. The focus points F_1 and F_2 of the lens are each 5 cm from the center of the lens.



(a) Determine the index of refraction of the lens material.

(b) The center of the lens and mirror are 20 cm apart, and an object (represented by the arrow in the above figure) is placed 8 cm to the left of the lens. Determine the position of the final image and its magnification as seen by the eye in the figure.

HINT: To determine the final image, note that light rays that originate from the object pass through the lens twice.

(c) Is the final image real or virtual? Is the final image inverted or upright?